Understanding Differences in User Preferences Across Water Systems in Rural Alaska

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ABSTRACT

Rural Alaskan water systems present unique challenges which differ from water systems in the contiguous United States. For instance, while prior literature is focused on piped water systems, water provision in rural Alaska is a multifaceted endeavor, whereby water is delivered not just via piped but also hauled and traditional methods. This study seeks to understand whether there are different sets of preferences attached to each of these water delivery methods. This paper uses qualitative interviews with 40 end-users in the YK Delta to identify relevant preferences across each of these systems based upon technical, economic, and social considerations. In terms of overall preferences, initial findings indicate those who use hauled systems are the most vocal of their desire for piped systems, not just for themselves but also for their entire community. In terms of socially driven preferences, while those who prefer hauled (and secondarily piped) methods most worry about water appearance, those preferring traditional methods most worry about taste of chlorine. In terms of technical-driven preferences, hauled and piped users are most concerned about freezing system components (and secondarily about pipe contamination). In terms of economic-driven preferences, while piped and hauled users tend to note their systems are expensive (some saying legitimately so), traditional users tend to note their systems as more affordable; this suggests cost is a differentiator in system choice. Identifying factors that differentiate end-user preferences will help utilities, planners, and decision-makers better select systems that align with the needs and interests of local communities in rural Alaska.

MOTIVATION

Recent significant attention and funding have been allocated to create and maintain water systems in ways that align to the preference of marginalized communities in rural Alaska. The United States Environmental Protection Agency (EPA) has committed $20 million USD to support the state of Alaska's proposed plan for key drinking water projects, and the Infrastructure Investment and Jobs Act (IIJA) /Bipartisan Infrastructure Law includes allocations of $65 million to Alaska's two State Revolving Fund programs (Corcoran 2022). Furthermore, $3.5 billion is being made available for the Indian Health Services sanitation facilities (Edgmon 2022) and an additional $2.76 billion is being made available for investment in water and wastewater infrastructure through the EPA's State Water Revolving Funds program (Lisa Murkowski Press Release 2022).

Alaska has received this financial investment to address substantial existing inequities of water provision throughout the state. Currently, Alaska has the highest proportion of homes without water and sewer services out of any state in the United States (Estus 2015). On average, 25 out of every 1,000 American Indian and Alaska Native households lacking running water, whereas the national average is an estimated three out of every 1,000 households which lack running water (Jones 2021). According to Alaska's Department of Environmental Conservation (AK DEC), there are currently more than 3,300 homes in rural Alaska which lack running water and a flushing toilet (AK DEC 2022). Most of these homes are concentrated in 32 "unserved communities", which AK DEC defines as communities where 45% or more of their homes are not served by piped water or hauled water and do not have a septic tank or well (AK DEC 2022). These unserved communities are largely located in rural areas that house mostly American Indian/Alaskan Native (AI/AN) populations. The funding being made available from the EPA and IIJA is earmarked specifically to address these issues of access and inequity within rural Alaska. In fact, the intention is to build water projects that attend to the needs and preferences of these 32 unserved communities.

While rural Alaska presents the need to understand and tailor to different community water preferences, the prior literature has largely focused on water access and benefits writ-large. For instance, prior studies extensively explore the general benefits of improving potable water access such as disease reduction, educational benefits, and overall improvements in quality of life (Hutton and Chase n.d.). Furthermore, economic savings from improved health conditions and the convenience of water availability have also been researched (Hutton and Chase n.d.).

However, rural Alaska presents idiosyncratic challenges and preferences amidst a varying array of system types. For instance, the AK DEC highlights that Southwest Alaska suffers among the highest rates of invasive pneumococcal disease (IPD) in the world, which they posit is associated with lack of in-home water and sewer service (AK DEC 2022). Additionally, the Alaska Native Tribal Health Consortium (ANTHC) notes that "access to clean water is an increasingly critical health care consideration for Alaska Native people" (ANTHC 2020). Despite the recognized

health and safety benefits of piped water from the prior aforementioned studies, hauled water and traditional water use systems are still largely used in the Yukon Kuskokwim Delta (YK Delta) (ANTHC 2020).

In light of this, our aim is to more carefully explore nuances in community preferences across a wider variety of systems of frequent use in a context such as rural Alaska. Especially given the sizable amount of funding now available for investment into water systems, understanding the nuance around community preferences for different water systems becomes even more imperative. As such, this research will provide insight into how preferences differ based upon the water system used (hauled, piped, or traditional) and the factors being considered (technical, economic, or social). The aim is that this study helps highlight parameters that could inform future community-specific evaluation and solutions that help more precisely guide these newfound water funding allocations moving forward.

Primary Water Systems in Rural Alaska

In this study, we focus on three primary types of water provision systems used in the YK Delta: piped systems, hauled water systems, and traditional water collection methods. Table 1 provides detailed descriptions for each system.

Table 1: Description of the three primary water delivery methods used in the YK Delta Region

System Type	Description
Piped water delivery system	Connects houses directly to the water treatment plant via permanent pipes. These systems resemble most of the water systems used in the contiguous U.S. (often locally referred to as the "Lower 48"). The main exception is that the pipes used in these systems are usually placed above ground and heated due to concerns with freezing temperatures in the tundra.
Hauled water delivery system	Water from treatment facilities is either delivered to the household by a delivery service (water trucks or an ATV and attached water trailer) or can be collected from the treatment facility or washeteria directly by an individual. The water is then stored in a personal storage tank at the household level.
Traditional water collection	Includes collecting rainwater from roof-catchments, collecting water from nearby fresh-water streams, and packing ice (the process of collecting chunks of ice from the tundra or nearby rivers during the winter and then thawing the ice chunks).

Note: Several communities also have private wells and collection points which we include in this analysis for completeness.

Examples of these systems are presented in Figures 1-3.

Figure 1: Piped water systems with above-ground pipes due to concerns with tundra freeze and melting causing subsidence

Figure 2: Left image: ATV pulling a water trailer. Right image: Water delivery truck. (company information hidden to ensure confidentiality)

Figure 3: Packed ice which is the process of collecting frozen chunks of ice and transporting them back to one's residence to be melted for water use in the home.

As noted previously, there is a notable gap in that prior literature does not adequately differentiate and nuance residents' preferences based upon different system types. Each system has an associated set of strengths and weaknesses that lead communities to perceive better or worse fit for their needs. By understanding residents' preferences across water delivery methods, city officials will be able to make more informed decisions about how the funding from the EPA and IIJA can most effectively develop and maintain systems that best meet community preferences.

METHODS

This study uses qualitative methods, as prior literature has yet to adequately classify differences in preferences as they align with water delivery systems in the YK Delta. To identify and classify these preferences, the research team conducted qualitative interviews with 40 end-users, defined here to be individuals who consume water and live in the YK Delta.[1] These interviews were conducted in-person in the YK Delta in April of 2022 and, on average, lasted for 30 minutes. The interviews were semi-structured based on a guided set of curated questions from the research team (protocol available upon request). Indicative questions to end-users included what systems they currently use, what they have used in the past, what they liked about their system, what they disliked about their system and the reasons for this. The 40 interviews were then transcribed and coded using an inductive content analysis approach (Spearing et al. 2022). Trends inductively emerged from this approach which shed insight into different user preferences for the varying water delivery types (Saldaña 2013). Across the 40 interviews, end-users used a variety of water delivery methods, including a combination of methods in some cases. Table 2 details these water delivery practices.

Table 2: Summary of end-user system usage

Water delivery method	Number of Interviewees
Hauled water only	18
Hauled water and traditional collection	4
Hauled water and piped water	1
Traditional collection only	5
Piped water and traditional collection	1
Piped water only	10
Piped water and well water	1

[1] 41 interviews were conducted but one was excluded when revealed the interviewee was not from the YK Delta.

RESULTS & DISCUSSION

Three major sets of preferences arose from the interviews, shedding light onto what end-users would like to see changed about their current systems. The first set of preferences, which included the most references across all 40 interviews fall into a category termed *social considerations*. These include concerns about the taste and smell of the water from given systems, the amount of water available from each system, the necessary effort required to manage each system, and water collection practices and sociocultural beliefs around water. The second major set of preferences which emerged pertained to *technical considerations*, which included challenges in operating and maintaining different water delivery methods in the Arctic environment and concerns about quality of the infrastructure itself. The final set of preferences which emerged were *economic considerations* which were primarily focused on the cost of each water delivery system for the end-user. Before we address such considerations, we will start by first identifying residents' overall preferences of specific water systems.

Systems Specifically Identified as Being Preferrable

Figure 4 shows that almost 40% of the end-users interviewed who used a hauled delivery system wanted to see piped water delivery systems for their entire (city) community, while only 15% of residents with piped systems and 10% of residents using traditional collection methods specifically stated this preference for the community as a whole. More than 20% of residents using the piped systems stated that they preferred the piped system over the hauled system, while 17% of residents using the hauled system stated that they preferred the hauled system over the piped system. Similarly, 20% of people using traditional collection methods preferred natural water over any kind of treated water. All graphs presented in the main body of the paper are normalized against the total number of respondents using a given system. These findings suggest that while there is a division in the preferences held for hauled and piped systems by those using hauled systems, more end-users suggested that they would like to see a shift to fully piped systems than those that would like to remain on hauled and traditional systems.

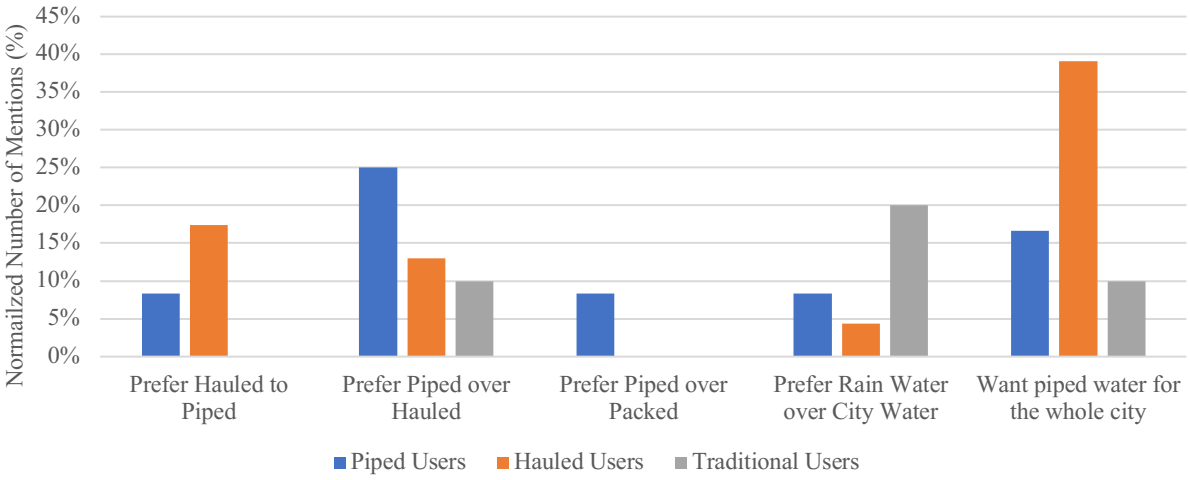

Figure 4: Instances where specific systems were identified as being preferable over another.

Social Considerations

Figure 5 presents the results from the qualitative coding which identify social considerations underlying some of the end-users' preferences. Here we see that one of the strong trends is the concern about water appearance. This especially is salient to hauled (48%) and piped users (22%), and has secondary concern to packed users (10%). While the visual appearance of water is not always an indicator of water quality, there are strong correlations between water appearance and how much trust users place in water quality (Smith et al. 1995). The high prevalence may suggest need for improved filtration or other treatments in systems to address these concerns about water appearance. Further investigation to ensure that the concerns are not further reaching and/or greater awareness of when appearance is an indicator of water quality may also be important considerations. In addition to mentions of visual aesthetic concern, traditional water collectors mention concern about the taste of chlorine with the highest frequency (40%). In fact, this was often a strong justification provided by people using traditional collection methods for wanting to continue using these methods. Traditional water collectors (20%) were also secondarily concerned with lack of unlimited water with other systems. This suggests that addressing the palpable taste of chlorinated water should be considered when building water systems in areas where end-users dislike the taste of chlorine.

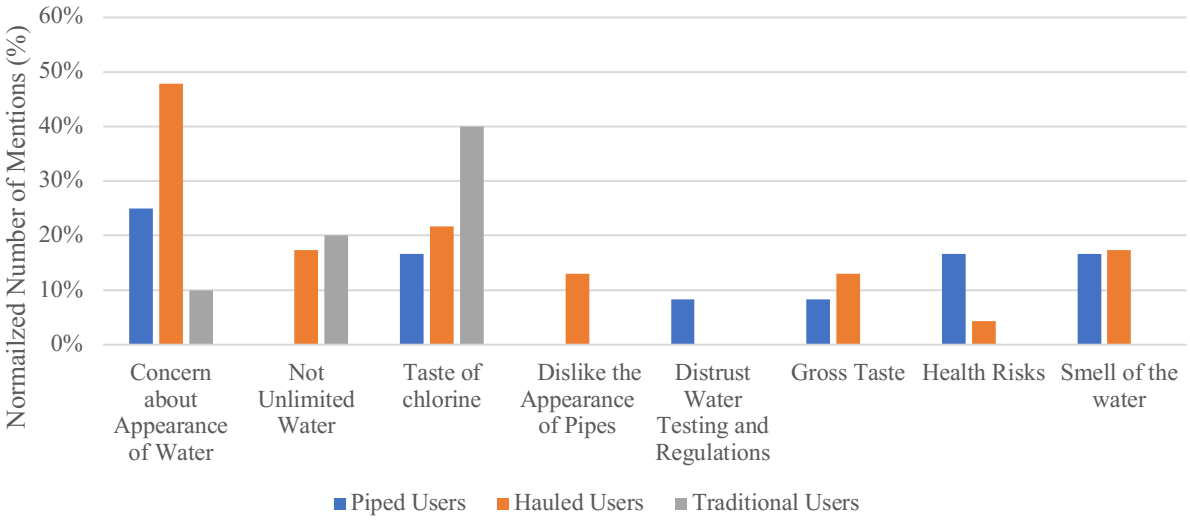

Figure 5: Social considerations for why end-users prefer different systems

Technical Considerations

We next explore the technical aspects which end-users note as being influential in their preferences for their system types. We see in Figure 7 that almost half of all respondents for both the hauled and piped systems mention issues with frozen system components. For the responses categorized under the traditional collection methods around frozen components, the responses presented were associated with two end-users who also use a hauled and piped system, and the comments pertained to the piped or hauled system rather than the traditional water collection approach. We see that 15% and 13% of piped and hauled system users respectively have

concerns about contaminated city pipes, with specific concern about pipe corrosion or rusting. Nearly 10% of hauled system users have concerns about potentially contaminated pipes within their home. Furthermore, 17% of hauled system users also have concerns about contaminated tanks within their own home. Additional monitoring, resource allocation, and even user training could be useful considerations here. Specifically, user training could include how to manage freezing system components and how to clean and maintain and in-home storage tank.

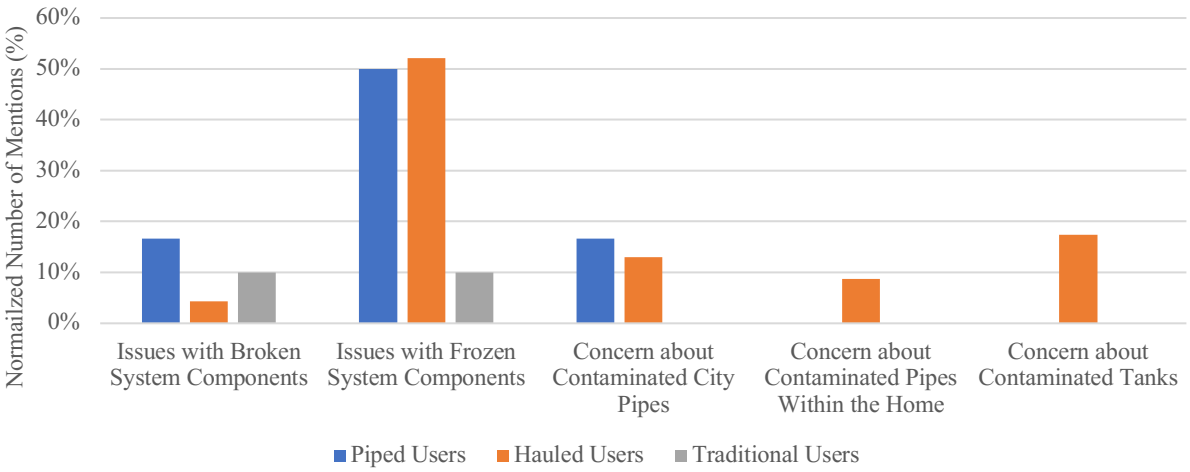

Figure 6: Technical considerations for preferences of water delivery system type

Economic Considerations

Finally, we address the economic considerations end-users give for their preferences around each system type. Overall, hauled and piped system users state that the cost of their water is more expensive than it is affordable (piped: 38% vs. 23%; hauled: 43% vs. 7%). Traditional water collectors state that their systems are more affordable than they are expensive (20% vs. 10%).

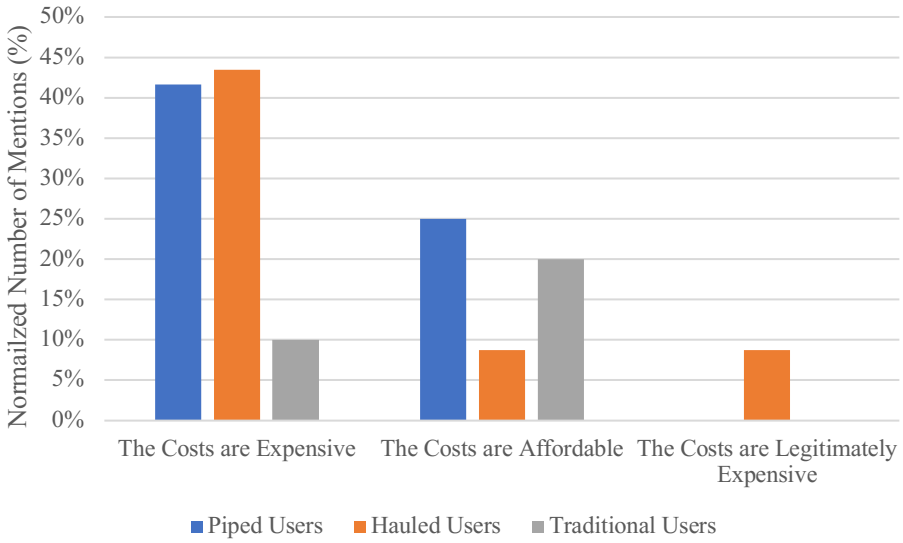

Figure 7: Economic considerations of each water delivery system

CONCLUSION

Given the recent significant funding made available for investment into water infrastructure projects throughout rural Alaska, understanding nuances in end-user preferences across different water delivery systems is crucial. However, prior literature does not adequately do this, given its more predominant focus on exclusively piped systems, which does not adequately reflect the diversity of water delivery methods prevalent in rural Alaska. We conducted and analyzed 40 semi-structured interviews with end-users in the YK Delta to understand their preferences for each system type across social, technical, and economic considerations. Initial findings indicate that among hauled system users, there is a strong desire for piped water systems to be spread to the entire community. Regarding social considerations, we see that almost 50% of the hauled water (and secondarily piped) users are concerned about water appearance. The taste of chlorine in water is a focus for 40% of traditional water collectors. Regarding technical considerations, hauled and piped water users experience issues with frozen system components. Of secondary though important note, more than 10% of both piped and hauled system users note concern about pipe contamination. Finally, more users across both the piped and hauled water system state that their water is expensive, whereas traditional water collectors more often note the affordability of their system. In light of these nuanced findings, this research may serve to better inform decision-making entities on how to allocate funding which better aligns with and considers nuanced user preferences and how they vary across water delivery system methods.

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